CHAPTER 22

STEEL

780 CMR 2201.0 GENERAL

2201.1 Scope: The provisions of 780 CMR 22 shall govern the materials, design, construction and quality of structural steel members.

780 CMR 2202.0 DEFINITIONS

2202.1 General: The following words and terms shall, for the purposes of 780 CMR 22 and as used elsewhere in 780 CMR, have the meanings shown herein.

Steel construction, cold-formed: That type of construction made up entirely, or in part, of steel structural members cold formed to shape from sheet or strip steel such as roof deck, floor and wall panels, studs, floor joists, roof joists and other structural elements.

Steel joist: Any steel structural member of a building or structure made of hot-rolled or cold-formed solid or open-web sections, or riveted or welded bars, strip or sheet steel members, or slotted and expanded, or otherwise deformed rolled sections

Steel member, structural: Any steel structural member of a building or structure consisting of a rolled steel structural shape other than cold-formed steel, light-gage steel or steel joist members.

780 CMR 2203.0 STRUCTURAL STEEL CONSTRUCTION

2203.1 General: Structural steel construction used in all buildings and structures shall be fabricated from materials of uniform quality which are free from defects that vitiate the strength or stability of the structure. All structural steel shall be designed and constructed in accordance with either the AISC *Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design*, hereafter referred to AISC ASD, or the AISC *Load and Resistance Factor Design Specification for Structural Steel Buildings*, hereafter referred to as AISC LRFD, listed in ***Appendix A***, except as modified by the provisions of 780 CMR 2204.0.

2203.2 Structural steel seismic requirements: The design of structural steel members and connections to resist seismic forces shall be in accordance with 780 CMR 2203.1 and the AISC *Seismic Provisions for Structural Steel Buildings*, listed in ***Appendix A***, except as modified by 780 CMR 2203.2.1 and 780 CMR 1616.

2203.2.1 Modifications to AISC seismic provisions: The AISC *Seismic Provisions for Structural Steel Buildings* shall be modified as indicated in items 1 through 8.

1. In Part 1, Section 2.1 of the AISC Provisions, replace the entire paragraph with the following: "All buildings assigned to Category C shall be designed in accordance with these provisions".

2. 780 CMR Table 1612.2.5 shall be used in lieu of Table 2-1 in Part I of the AISC Provisions.

3. In Part 1, Section 3.1, of the AISC Provisions, delete the entire section, except for Load Combinations 3-7 and 3-8 and replace with 780 CMR 1616.3. Replace load combinations 3-7 and 3-8 as follows;

1.3 Dead+1.0 Floor Live+0.7 Snow +/-(2R/5) Seismic (3-7)

$$(0.9 - 0.5\ A_V)\text{Dead} +/- (2R/5)\ \text{Seismic} \quad (3\text{-}8)$$

The term (2R/5) shall be greater than or equal to 1.0

4. In Part I, Section 6.1, of the AISC Provisions, replace equation 6-1 with the following:

1.3 Dead+1.0 Live+0.7 Snow+(2R/5)

Seismic ? $F_c P_n$ (6-1)

5. In Part I, Section 6.1, of the AISC Provisions, replace equation 6-2 with the following:

(0.9 - 0.5A_v) Dead - (2R/5)Seismic

? $F_t P_n$ (6-2)

6. In Part 1, Sections 6.2, 7.1, 8.1 and 9.1 of the AISC Provisions, replace all references to Load Combinations 3-1 through 3-6 with the following; "...Load Combinations 1 through 8 of 780 CMR 1616.3.1".

7. In Part 1, Sections 8.3a, 9.4a, 9.4b and 10.8, and in Part II, Section 7.1 of the AISC Provisions, replace all references to Load Combinations 3-5 and 3-6 with the following; "...Load Combinations 7 and 8 of 780 CMR 1616.3.1".

8. In Part 1, Sections 8.7b of the AISC Provisions replace the reference to Load Combination 3-5 with the following; "...Load Combination 7 of 780 CMR 1616.3.1".

9. Special provisions for Welded Steel Moment Frames: Recent experience has shown that prequalified, welded beam-to-column moment connections used for Moment Resisting Frames are much more susceptible to damage than originally thought when the AISC Provisions were published. The current state of knowledge indicates that the welded beam-to-column moment connections depicted in the AISC Provisions, Commentary Section 8, do not provide the level of ductility required by the Provisions for buildings that will be subjected to repeated cycles of inelastic deformation during an earthquake.

Welded beam-to-column moment connections for Special Moment Resisting Frames, Eccentrically Braced Frames and Dual Systems with Special Moment Resisting Frames shall be designed in accordance with 780 CMR 2203.2.1, Item 10.

Welded beam-to-column moment connections for Ordinary Moment Resisting Frames shall be designed in accordance with 780 CMR 2203.2.1, Item 11.

10. Design of Special Moment Resisting Frames: The design of Special Moment Resisting Frames, Eccentrically Braced Frames and Dual Systems with Special Moment Resisting Frames shall follow the procedures of the Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment Frame Structures (FEMA 267/August, 1995), except as noted herein. Chapter 7 of this document offers guidance for the design of new buildings with welded moment frames and Chapter 8 addresses metallurgy and welding. The following exceptions and clarifications shall apply to FEMA 267/August, 1995.

1. All buildings with welded beam-to-column moment connections, including light single story buildings, shall be considered to be susceptible to connection failure. The welded beam-to-column connections depicted in the AISC Seismic Provisions, Section 8, Commentary shall be prohibited for Special Moment Resisting Frames.

Exceptions: Buildings that will remain elastic when subject to dead and live loads, together with full seismic load, computed with R=1. An analysis that demonstrates that all components of the structure and its connections have adequate strength to resist these loads shall be submitted and approved. In addition, the requirements of 780 CMR 2203.2.1, Item 11, shall be applicable.

2. Welded steel beam-to-column moment connection details used in the design of buildings with Special Moment Resisting Frames shall be sufficiently verified by tests of connections with similar geometry and member size. The example designs shown in Section 7.9 of FEMA 267/August

1995 shall not be permitted unless adequate data showing acceptable performance has been submitted and approved.

3. The construction documents shall set forth the connection geometry and specific design procedures demonstrating that the connections meet the design intent and comply with all requirements of 780 CMR.

11. Design of Ordinary Moment Resisting Frames: Welded beam-to-column connections depicted in the AISC Provisions, Section 8 Commentary shall be allowed for Ordinary Moment Resisting Frames provided the following provisions are met:

1. Filler metal used in critical welds, including all full penetration welds, in beam-to-column connections shall have a minimum Charpy V-Notch value of 20ft-lbs at 40?F for fully enclosed and heated buildings and 20 ft-lbs at zero degrees Fahrenheit for other buildings or structures.

2. Backer bars shall be removed at all bottom flange welds made in the down hand position, and the root pass shall be back gouged and re-welded. A reinforcing fillet weld shall be added at the top and bottom of bottom flange full penetration welds.

3. A reinforcing fillet weld shall be added at the top of top flange full penetration welds.

4. The construction documents shall set forth, in sufficient detail, the connection geometry and specific design procedures demonstrating that the connections meet the design intent and comply with all requirements of 780 CMR

2203.3 Temporary and special stresses: Provision shall be made in the design of structural steel construction for temporary stresses that occur during erection, and for the influence of special *loads* producing impact or vibrations as provided for in 780 CMR 1614.0. Stresses caused by eccentric loading shall be fully provided for and eccentric details shall be shown on the design and shop drawings.

2203.4 Shop drawings: Complete shop drawings shall be prepared in compliance with the best modern practice in advance of the actual fabrication. Such drawings shall clearly distinguish between shop and field rivets, bolts and welds in all connections and details.

2203.5 Painting and special protection: All painting shall comply with the requirements contained in AISC ASD or AISC LRFD listed in ***Appendix A***. Where exposed to highly corrosive fumes or vapors, or where subject to destruction from other highly hazardous industrial processes, all structural steelwork shall be protected by an approved method.

780 CMR 2204.0 SEISMIC REQUIREMENTS FOR STRUCTURAL STEEL

2204.1 General: Steel structural elements that resist seismic forces shall be designed in accordance with the applicable provisions of 780 CMR 2203.0, 2205.0, 2206.0 and 2207.0.

780 CMR 2205.0 OPEN-WEB STEEL JOIST CONSTRUCTION

2205.1 General: Steel joists and joist girders used as structural members in floor and roof construction shall be designed and constructed in accordance with SJI *Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders* listed in ***Appendix A***.

2205.2 Partitions: The joists shall be designed to support the *dead load* of partitions, wherever they occur, in addition to all other imposed *dead* and *live loads*.

2205.3 Protection: Painting of steel joists shall be in accordance with the requirements of 780 CMR 2206.4 for formed steel construction.

2205.4 Tests: Where not subject to approved engineering analysis as regulated by 780 CMR 2205.1, the assembly shall meet the load test requirements specified in 780 CMR 1709.0 and 1710.0.

780 CMR 2206.0 FORMED STEEL CONSTRUCTION

2206.1 Design: The design of all cold-formed carbon and low-alloy steel structural members and assembled wall, floor and roof panels, used alone or in combination with other structural members, or with component materials, shall be in accordance with the AISI *Specification for the Design of Cold-Formed Steel Structural Members*, allowable stress design, hereafter referred to as AISI CFSD-ASD or the AISI *Load and Resistance Factor Design Specification for Cold -Formed Steel Structural Members* hereafter referred to as AISI CFSD-LRFD, listed in ***Appendix A***, except as modified by the provisions of 780 CMR 2206.0. The design of all cold-formed stainless steel structural members and components shall be based on a load and resistance factor design method or an allowable stress design method and maximum deflections in accordance with the ASCE *Specification for the Design of Cold Formed Stainless Steel Structural Members*, hereafter referred to as ASCE 8-SSD-LRFD, or ASCE 8-SSD-ASD listed in ***Appendix A***, except as modified by the provisions of 780 CMR 2206.3 and 2206.3.1.

2206.1.1 Composite slabs: Composite slabs of concrete on steel deck shall be designed and constructed in accordance with ASCE 3 listed in ***Appendix A***.

2206.2 Secondary structural systems: Formed steel floor, wall and roof systems are permitted to be designed and constructed to resist all vertical and horizontal moments and shears resulting from lateral forces. Such members, where designed to transmit horizontal shears due to wind or other lateral forces, shall be connected to the supporting structure so as to resist adequately all primary and secondary stresses. Where concrete topping or other approved decking is installed and strength of the composite member is included in the calculations, the concrete topping or decking shall be installed in such a manner as to insure composite action of the assembly

2206.3 Cold-formed steel structural member seismic requirements: The AISI CFSC-LRFD and ASCE 8-SSD-LRFD listed in ***Appendix A*** for the design based on the load and resistance factor design method, and the AISI CFSD-ASD and ASCE 8-SSD-ASD listed in ***Appendix A*** for the design based on the allowable stress design method, shall be modified as indicated in this section. The references to sections and paragraph numbers are to those of the particular specification modified.

1. AISI CFSD-ASD: The nominal strength of members and connections shall be in accordance with AISI CFSD-ASD, except that the nominal strength for shear and web crippling shall be determined by multiplying the allowable strength by 1.7. Design strengths shall be determined by multiplying the nominal strengths by the following resist ance factors:

Shear strength for $h/t > (Ek_V/F_y)^{½}$ 0.9
Shear strength for $h/t \leq (Ek_V/F_y)^{½}$ 1.0
Web crippling for members with single unreinforced webs..... 0.75

Web crippling for "I" sections..... 0.80
All other cases.....1.55/Factor of Safety

The notation shall have the same meaning as in AISI CFSD-ASD.

2. **Load factors**: Modify Section A5.1.4 in AISI CFSD-LRFD by substituting a *load* factor of 1.0, in place of 1.5, for nominal *earthquake loads*.

2206.3.1 Steel deck diaphragms: Steel deck diaphragms shall be made from materials conforming to the requirements of AISI CFSD-ASD, AISI CFSD-LRFD or ASCE 8-SSD- ASD listed in ***Appendix A***. Nominal strengths shall be determined in accordance with approved test procedures developed by a *registered design professional*. Design strengths shall be determined by multiplying the nominal strength by a resistance factor of 0.60.

The steel deck installation for the building, including fasteners, shall comply with the test assembly arrangement.

2206.3.2 Light gage steel-framed walls: Cold-formed steel stud walls in buildings assigned to Seismic Performance Category D in accordance with 780 CMR 1612.2.7 shall comply with 780 CMR 2206.0 and the following requirements:

2206.3.2.1 Boundary members: All boundary members, chords and collectors shall be designed to transmit the induced axial force.

2206.3.2.2 Connections: Connections for diagonal bracing members, top chord splices, boundary members and collectors shall be designed to develop the tensile strength of the member or, in those cases where (2R/5) is equal to or greater than l .0, (2R/5) multiplied by the design seismic force, where R is the response modification factor determined from Table 1612.4.4. The pull-out resistance of screws shall not be used to resist seismic forces.

2206.3.2.3 Braced bay members: Vertical and diagonal members in braced bays shall be

3. The strength of stainless steel structural members and connections subject to seismic forces in combination with other prescribed *loads* shall be determined by the provisions of ASCE 8-SSD-LRFD, except that combinations of *load* effects shall comply with the requirements of 780 CMR 1616.0.

anchored such that the bottom track is not required to resist uplift forces by bending of the track web. Both flanges of studs shall be braced to prevent lateral torsional buckling.

2206.4 Protection: Formed steel shall be protected in accordance with 780 CMR 2206.4.1 through 2206.4.4.

2206.4.1 Shop coat: All individual structural members and assembled panels of light gage and formed steel construction, except where fabricated of approved corrosion-resistant metallic steel or of steel having a corrosion-resistant or other approved coating, shall be protected against corrosion with an approved shop coat of paint, enamel or other approved protection.

2206.4.2 Field coat: After erection where directly exposed to the weather, except where encased in concrete made of non-corrosive aggregates, or where fabricated of approved corrosion-resistant steel, or of galvanized or otherwise adequately protected steel, individual structural members and assembled panels of light gage and formed steel construction shall be given an additional coat of approved protection.

2206.4.3 Siding: Exposed siding or sheathing shall be fabricated of approved corrosion-resistant steel or otherwise protected at the ground level for sufficient height above grade as determined by the depth of average snowfall in the locality, but not less than eight inches (203 mm).

2206.4.4 Protection at exterior walls: Floor or roof construction which extends into an exterior

wall shall be adequately waterproofed and protected from the weather to prevent corrosion.

2206.5 Tests: Where not capable of design by approved engineering analysis, the code official shall require tests of the individual or assembled structural units and the connections as prescribed in 780 CMR 1709.0 and 1710.0. At least three specimens truly representative of the construction to be used in practice shall be subjected to the prescribed test and the mean of the results shall determine the safe working value; provided that any individual test varying more than 10% from the mean value shall cause rejection of the series.

2206.6 Identification: Each structural member, siding panel and roof panel of a metal building system, other than hardware items such as bolts. nuts, washers, shims and rivets, shall be identified by the manufacturer. The identification shall include the manufacturer's name or logo, and the part number or part name consistent with assembly instructions.

780 CMR 2207.0 SPECIAL STEEL AND STEEL CABLE STRUCTURAL SYSTEMS

2207.1 Special steels: Alloy, high-carbon or other special high-strength steels not covered in 780 CMR 22, where used in the design and construction of

3. The effective design breaking strength in Section 6 shall be multiplied by the following resistance factors:

Members, connections and base plates that develop the strength of the members of structural systems	0.90
Connections that do not develop the strength of the member or structural system, including connections to base plates, and anchor bolts	0.67

780 CMR 2208.0 CAST-STEEL CONSTRUCTION

buildings and structures, shall conform to 780 CMR 1706.0.

2207.2 Structural steel cable systems: The design, fabrication and erection of steel cables used as loadbearing members in buildings and structures shall be in accordance with the AISI *Criteria for Structural Applications of Steel Cables for Buildings* listed in ***Appendix A***, except as modified by the provisions of 780 CMR 2207.2.1.

2207.2.1 Steel cable seismic requirements: The AISI *Criteria for Structural Applications of Steel Cables for Buildings* listed in *Appendix A* shall be modified as indicated in 780 CMR 2207.2. The references to sections are those of the AISI *Criteria for Structural Applications of Steel Cables for Buildings* listed in ***Appendix A***.

1. *Load* combination "d." of Section 5 shall be modified by substituting $1.5T_4$ instead of $2.0T_4$, where T_4 is the net tension in the cable due to *dead load*, prestress, *live load* and seismic *load.*
2. A *load* factor of 1.1 shall be applied to the prestress forces to be added to the *load* combination in Section 3 of the steel cable specification.

2208.1 Materials: Carbon steel casting for building construction shall be cast from steel conforming to AISC ASD or AISC LRFD listed in ***Appendix A***. All castings shall be free from injurious blow holes or other defects which will impair the structural strength.

2208.2 Higher strength cast steel: Higher strength cast steel shall not be used unless approved.

2208.3 Welding cast steel: Cast steel designed for use in welding shall be of weldable grade.

780 CMR 2209.0 CAST-IRON CONSTRUCTION

2209.1 Materials: Cast iron for building construction shall be a good foundry mixture providing clean, tough, gray iron that is free from serious blow holes, cinder spots and cold shuts, and that conforms to ASTM A48 listed in ***Appendix A*** for medium gray-iron castings.

2209.2 Limitations of use: Cast-iron columns shall not be used where subject to eccentric *loads* that produce a net tension in the section, nor in any part of a structural frame that is required to resist stress due to wind. The maximum stresses for cast iron shall be as indicated in Table 2209.2.

Table 2209.2
CAST-IRON STRESSES

Type of stress	Maximum stress (psi)[a]
Extreme compression (fiber stress in bending)	16,000
Extreme tension (fiber stress in bending)	3,000
Column compression	9,000 minus 40(*l*/*r*)
Shear	3,000
Tension	3,000

Ratio *l*/*r* not to exceed 70

Note a. 1 psi = 6.895 kPa.

2209.3 Multistory columns: Cores of superimposed columns shall be of the same dimensions above and below a splice. Where a column of smaller diameter is superimposed over one of larger diameter, the larger column shall be tapered down to the smaller diameter over a length of not less than six inches (152 mm).

2209.4 Thickness of metal: The minimum thickness of cast iron shall not be less than specified in 780 CMR 2209.4.1 through 2209.4.3.

2209.4.1 Columns: In columns, the metal shall not be less than one-twelfth of the smallest dimension of the cross section and not less than ¾ inch (19 mm).

2209.4.2 Bases and brackets: In bases and flanges, the metal shall not be less than one inch (25 mm) thick, and shall be reinforced with fillets and brackets.

2209.4.3 Lintels: In lintels, the metal shall not be less than ¾ inch (19 mm) thick, and shall be limited to use on spans of not more than six feet (1829 mm).

2209.5 Inspection: A cast-iron column shall not be erected in place before such column has been inspected and approved. The use of any cast-iron column in which blow holes or imperfections reduce the effective area of the cross section more than 10% shall be prohibited. Where required by the code official, ?-inch (10 mm) round inspection holes shall be drilled in the section to expose the thickness of metal for inspection purposes.

780 CMR 2210.0 EXTERIOR STEEL FRAME CORROSION PROTECTION UNDER MASONRY

2210.1 Required: Exterior steel columns and girders, before embedment in masonry of the required fireresistance rating specified in Table 602, shall be protected from moisture by an approved waterproofing material, a parging coat of cement mortar or by a minimum of eight inches of weather-tight masonry.

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